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ORBIT INCLINATION CHANGE OF LUNAR PROBES UTILIZING EARTH'S GRAVITY

Abstract

There is a history of using the Moon's gravity to change the orbital inclination of Earth's satellites [1], but there is much less study on using the Earth's gravity to change the orbit inclination of lunar probes. In this work, by taking the transfer from an initial orbit with an orbit inclination of 30 degrees to a polar lunar orbit as an example, this problem is studied. To simplify the study, only two maneuvers (at the departure and the arrival point respectively) are considered

In Ref [2], a similar problem was already studied in the Jupiter-Europa system which has a much larger mass difference than the Earth-Moon system. By using Jupiter's gravity, the energy to change the orbit inclination of a probe around Europa can be obviously saved. In this paper, the same method is used. The model, however, is changed from the Hill model to the circular restricted three-body problem. Moreover, the possibility to further reduce the energy by multiple use of Earth's gravity is discussed. Our studies show that the energy can be mildly saved by multiple use of the Earth's gravity.

Actually, the method in Ref [2] uses the type of non-transfer orbits around the collinear libration points L1 or L2 of the Earth-Moon system. We can also use the invariant manifolds or the transfer orbits associated with periodic or quasi-periodic orbits around the collinear libration point to change the lunar orbit inclination. For the invariant manifolds, studies show that they are not very good at changing the orbit inclination due to two reasons: (1) the extent of orbit inclination change is limited, and (2) the transfer time is usually long. For the transfer orbits, the transfer orbit firstly leaves out of the Moon's Hill sphere, enters the region dominated by the Earth's gravity, and then enters the Moon's Hill sphere and goes to the perilune point again. Studies show that the orbit inclination can also be changed greatly by the transfer orbits, but the transfer time is usually longer than the method in Ref [2]. Moreover, since the transfer orbit requires the opening of the L1 or L2 gate, the energy is generally higher than that of the method in Ref [2].

[1] Ocampo C.A., Acta Astronautica, 2003, 52, 173-179
[2] Villac B.F., Scheeres D.J., Journal of Guidance, Control, and Dynamics, 2003, 26, 750-757